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## HIGH SPEED VERTICAL PROCESSOR

### Field Of The Invention

[0001] The present invention relates to apparatus for high speed processing of products and, more particularly, to an improved vertical axis processor which includes an lid lift assembly.

### Background Of The Invention

[0002] Various processes and machines have been developed over the years to provide processing of the surfaces of products. Some processing machinery use the centrifugal force imparted by a rotating vessel, in combination with an abrasive media, to finish products. A number of these machines subject objects to both centrifugal and rotational forces using a complex gearing arrangement. These types of machines are limited to a particular ratio of revolutional speed to rotational speed. Also, the construction of these existing machines is complicated requiring many moving parts, and are generally extremely noisy. Other types of machines create centrifugal forces by revolving a vessel around a shaft and creating rotational forces using a belt wrapped around the shaft and the exterior of the vessel. In this type of design, the speed of the belt is directed related to the speed of the shaft. As such, excessive speed can result in overheating of the machines.

[0003] One of the key deficiencies with many of the prior art machines is that the rotating components are supported by bearings. As such, the speed and operational life of those machines is limited to the maximum capability of the bearings. Also, bearings tend to not tolerate vibration very well. As such,

machines which utilize bearings to support the rotating containers operate fairly slow.

[0004] One successful machine using both centrifugal and rotational forces in a simple design, without a system of gears and which can be operated at very high speeds, is disclosed in U.S. Pat. No. 5,355,638 to Hoffman, the disclosure of which is hereby incorporated by reference in its entirety. As disclosed in that '638 patent, the centrifugal vertical finisher (or polisher) has an outer vessel that is rotatable, and at least one inner vessel that is revolved about the axis of the rotatable outer vessel and rotated about its own axis. A traction surface exists between the inner surface of the outer vessel and the outer surface of the inner vessel. The traction surface allows the outer vessel to restrain the inner vessel while the inner vessel experiences centrifugal forces. This machine simultaneously uses the momentum caused by the speed and potentially direction differential between the outer and inner vessels to produce revolution of the inner vessel.

[0005] The '638 patent also discloses an apparatus where a center drive can be used for rotating the outer vessel and the inner vessel.

[0006] Another successful machine using both centrifugal and rotational forces is disclosed in U.S. Pat. No. 5,848,929 to Hoffman, the disclosure of which is hereby incorporated by reference in its entirety. The '929 patent discloses a centrifugal vertical finisher with a fixed outer vessel that permits much larger objects to be finished without the need to apply excessive energy and force to the unit. Additionally, the device in the '929 patent permits the inner vessel to be removed so that vessels of various diameters can be used in the unit without necessarily having to change the outer vessel.

[0007] Although the '638 and '929 patents provide a significant advancement in the field of rotational processing, these machines do not describe any mechanism for automating the opening and closing of the barrels or vessels for ease of loading and unloading of products and media.

[0008] A need, therefore, exists for an improved vertical processor which includes an automated lid system for facilitating access to the interior of the processing containers.

### **Summary Of The Invention**

[0009] The present invention relates to an improved vertical processor for processing parts by subjecting the parts to rotational and centrifugal motion with an abrasive media. The vertical processor includes an outer drum which has an inner surface, and a plurality of inner containers located within the outer drum and adapted to be driven into engagement with inner surface of the outer drum by centrifugal motion. The engagement between the inner containers and the outer drum inducing rotational motion to the containers. Each container has an open top.

[0010] A drive system is provided for centrifugally driving the inner containers against the drum. The drive system can also be used to rotate the outer drum, thereby further enhancing the motion of the containers.

[0011] Each container includes a lid that is adapted to removably engage with the container for closing the container. The lids are attached to a lifting mechanism which is designed to lift the lids off of the container.

[0012] The foregoing and other features of the invention and advantages of the present invention will become more apparent in light of the following detailed description of the preferred embodiments, as illustrated in the accompanying figures. As will be realized, the invention is capable of modifications in various respects, all without departing from the invention. Accordingly, the drawings and the description are to be regarded as illustrative in nature, and not as restrictive.

### **Brief Description Of The Drawings**

[0013] For the purpose of illustrating the invention, the drawings show a form of the invention which is presently preferred. However, it should be understood that this invention is not limited to the precise arrangements and instrumentalities shown in the drawings.

[0014] Figure 1 is an isometric drawing of a vertical processor according to the present invention.

[0015] Figure 2 is an isometric view of the vertical processor of Figure 1 with the outer framing covers removed to illustrate the frame structure.

[0016] Figure 3 is an isometric view of the vertical processor of Figure 1 with the frame structure and drum removed to clearly illustrate the lid mechanism and drive system for the processor.

[0017] Figure 4 is a side cross-sectional view of the processor taken along lines 4-4 in Figure 1.

[0018] Figure 5 is a top cross-sectional view of the processor taken along lines 5-5 in Figure 1

[0019] Figure 6A is a side view of a container with a portion of the lid assembly shown.

[0020] Figure 6B is a side view of the container of Figure 6A with the lid in its open position.

#### **Detailed Description Of The Preferred Embodiments**

[0021] Referring now to the drawings, wherein like reference numerals illustrate corresponding or similar elements throughout the several views, Figures 1 and 2 are isometric views of a vertical processor 10 according to one embodiment of the present invention. The vertical processor 10 includes a frame assembly 12 which forms a support structure and safety housing for the processor. The frame assembly 12 includes frame covers 14 which are attached to a frame structure 16. One or more of the covers may be removable from the

frame structure to facilitate access to the processor. In the illustrated embodiment, the frame assembly 12 forms an enclosure within which the processing assembly 18 is located. The covers limit access to the processing assembly 18 so as to inhibit foreign objects from entering the processing assembly 18.

[0022] The frame structure 16 is preferably made from tubular steel or other high strength components. As shown in Figure 2, the frame structure includes vertical columns 20 and horizontal beams 22. The columns 20 include feet 24 which are preferably designed to be secured to the ground. The feet 24 may include vibration isolators, such as rubber, to minimize or attenuate the transfer of vibration from the frame structure 16 to the ground. The beams 22 are attached to the columns 20 using any conventional mechanism, such as welding. The beams 22 are preferably grouped so as to form a box structure as shown in Figure 2. This type of arrangement provides strong support for reacting the various loads imposed on the frame structure 16 by the processor.

[0023] Referring now for Figure 3, an isometric view of the processing assembly 18 is shown. As will be described in more detail below, the processing assembly 18 includes a rotational processor 26, a drive mechanism 28 and a lid assembly 30. For clarity the outer annular ring or drum is not shown in Figure 3. The drum forms part of the rotational processor 26 as described below. The frame structure 16 preferably supports each of these components, thus providing a self-contained assembly.

[0024] The rotational processor 26 is illustrated in more detail in Figures 3 and 4. The rotational processor 26 includes an outer annular ring or drum 32. For simplicity, the ring or drum will be referred to as an outer drum. While the illustrated embodiment includes a cylindrical drum, any shape drum can be used. As is described in detail in U.S. Pat. Nos. 5,355,638 and 5,848,929, the entire disclosures of which are incorporated herein by reference in their entirety, the outer drum provides a surface upon which a processing container can roll along. The outer drum 32 is either fixed or, more preferably, rotatably mounted to or supported by the frame structure 16. A plurality of inner processing containers or vessels 34 are located within the outer drum 32. The inner

containers 34 are mounted so as to be driven independently from the outer drum 32 as will be described in more detail below. In the illustrated embodiment, the inner surface of the outer drum 32 is cylindrical in shape. As such, the inner container 34, which is also preferably cylindrical, is driven around the inner circumference of the outer drum 32 (i.e., rolls along the inner surface) and, thus, is rotated about the central axis of the outer drum.

[0025] The outer drum 32 is preferably disposed about a central drive shaft 36. The drive shaft 36 is mounted to the frame structure 16 through one or more bearings 38 and, as such, can rotate about its vertical axis relative to the frame structure. A drum shaft 40 is disposed about a portion of the drive shaft 36. The drum shaft 40 is supported by two bearings 42 which are mounted to beams. The drum shaft 40 is free to rotate relative to the drive shaft 36, as well as the frame structure 16. The drum 32 is attached to the drum shaft 36 through a drum mount 42. The drum mount 42 is attached to the drum shaft 40 and drum 31, such that the drum 32 and the drum shaft 40 rotate in combination with one another.

[0026] One or more rollers 44 (shown in Figure 3) are mounted to the frame structure 16 and located so as to contact the outer surface of the drum 32. The rollers 44 provide lateral support for the drum while permitting rotation of the drum about the central axis.

[0027] The outer drum and drum shaft are preferably made from high strength material which can withstand high centrifugal loads, such as steel.

[0028] Referring now to Figure 5, a top view of the rotational processor 26 is shown illustrating the turret mounting arrangement of the inner containers 34. More particularly, a center disk 46 is attached to the drive shaft 36 through a container mount 48 such that the center disk 46 and drive shaft 36 rotate in combination with one another.

[0029] The containers 34 are mounted about the periphery of the center disk 46. The mounting arrangement is similar to the mounting arrangement shown in U.S. Pat. No. 5,355,638, however the present invention incorporates a pivot connection. More specifically, a plurality of clevis mounts 50 are attached

to the center disk 46 at spaced apart circumferential positions. As shown, each clevis mount 50 is associated with one container 34. As should be readily apparent, the clevis mounts 50 and containers 34 are preferably arranged so as to be substantially balanced about the drive shaft 36. Each clevis mount 50 includes two spaced apart legs 52. The legs 52 are designed to extend about a lift arm 54 as shown in Figures 5 and 6A.

[0030] A pin 56 extends through each leg and the lift arm 54, thereby providing a pivotable or hinged connection between the lift arm 54 and the clevis mount 50. Thus, the lift arm can pivot about an axis that runs through the center of the pin which, in the illustrated embodiment, is horizontal. The lift arm 54 is attached to a bearing block 58 through any conventional fastening mechanism, such as bolts.

[0031] The inner container 34 is similar to the container described and illustrated in the '638 patent. Thus, no further discussion is needed regarding the specifics of the container. A mounting pin or axle 60 is mounted to and extends downward from the bottom of the container 34, substantially in its center. The axle 60 is designed to slide into at least one and, more preferably, two bearings 61 formed in a hole in the bearing block 58.

[0032] The bearings 61 are designed to provide initial location and alignment of the container 34 relative to the drum. More specifically, the goal of the axle 60 and bearings 61 is to provide parallelism between the vertical axis of the container and the vertical axis of the drum so that the contact between the container 34 and the drum 32 is substantially along a vertical line of contact. This provides the most efficient mechanism for transferring load during operation.

[0033] One of the primary benefits of the present invention is to provide for reaction of the centrifugal loading principally (and preferably almost entirely) through the interaction of contact between the inner container 34 and the drum 32. This type of support essentially removes all loading from the bearings that support the container, thus allowing the container to withstand a considerable higher amount of loading than would otherwise be possible.

[0034] By providing initial parallelism between the vertical axes, the bearings provide support only while the centrifugal loads are less than loads due to the weight of the container (and contents). Once the centrifugal loads are higher than these container loads, the container support is transferred to the drum. However, if the container axis and the drum axis are not aligned, there may be some residual loading on the bearings since there is a slight pressure angle. The present invention utilizes the bearings 61 and axle 60 to provide the initial alignment of the container 34 relative to the drum 32.

[0035] Referring now to Figures 3, 4, 6A and 6B, the lid assembly 30 is designed to provide automated opening and closing of the containers 34. The lid assembly 30 includes a plurality of lids 62 that are designed to mate with and substantially seal against the open tops of the containers 34. Each lid 62 includes a cover plate 64 and a substantially conical seal 66. The conical taper of the seal 66 assists in providing a good sealing surface between the container 34 and the lid 62. The seal 66 is preferably made from a resilient material, such as an elastomer (e.g., rubber), urethane or foam, although other types of seal material may be used. It has been found that the use of a softer rubber, such as 70 durometer versus 95 durometer, works well at providing a tight seal and allows for the incorporation of fairly tight tolerance bearings 61. This results in a significantly quieter system.

[0036] The lid 62 is attached to a lift block 68 with a bolt or other conventional fastener. A thrust bearings 69 are mounted in the lift block 68 and receive the fastener. The thrust bearings 69 are designed to retain the lid 62 on the lift block 68, while permitting the lid to rotate in combination with the container 34.

[0037] The lift block 68 is attached to the upper end of the lift arm 54 though a hinge. As such, the lid 62 can be pivoted away from the top of the container 34 as shown in Figure 6B, thereby permitting access to the interior of the container 34. The pivoting of the lid away from the container 34 also permits the container 34 to be removed and replaced relatively easily. Another benefit of the lid assembly in the present invention is that the lift block 68 is designed to force the lid 62 onto the container 34 during operation. More



specifically, by locating the hinge on the lift block 68 at a point below the plane of the lift block 68, the centrifugal or gyratory forces exerted on the lift block 68 during operation tend to drive the lift block down onto the container. This provides a significant safety advantage since, should the lid or hinge break during operation, the lid will not fly off. Instead, it will remain in place until the machine is turned off.

**[0038]** A lug 70 is formed on the lift block 68. As shown in the figures, a gas spring 72 is pinned at one end to the lug 70. The opposite end of the gas spring 72 is pinned to a lift plate 74. The gas spring 72 is preferably an MCM 9416K14 and is designed to provide for proper sealing of the lid 62 to the container 34 by permitting a desired amount of preload to be applied when the lid 62 is closed. The preload forces the tapered seal 66 to seat properly on the container. Also, because of the angular orientation of the gas spring 72 relative to the container 34, and the fact that the container 34 is hinged to its support, the gas spring 72 urges the container 34 into contact with the inner surface of the drum 32. Thus, immediately upon closing the container 34, the container 34 is in contact with the drum and, as a consequence, operation of the machine produces immediate prolate cycloid motion of the parts within the container, maintaining the parts away from the walls of the container 34.

**[0039]** The lift plate 74 is preferably disposed about an upper portion of the drive shaft 36. In the illustrated embodiment, a spline shaft 76 is attached to the upper end of the drive shaft and extends upward through the lift plate 74. The lift plate 74 is attached to the spline shaft 76 such that the lift plate 74 and drive shaft 36 rotate in combination with one another. More particularly, a splined linear bearing 78 is used to attach the lift plate 74 to the spline shaft 76. The linear bearing 78 permits the lift plate 74 to move vertically relative to the spline shaft 76, while at the same time transfers rotational motion from the spline shaft 76 to the lift plate 74.

**[0040]** A lift mount 80 is attached to the lift plate 74. At least one and more preferably a plurality of shafts 82 are attached at one end to the lift mount 80. The shafts 82 are attached at their opposite end to an upper lift plate 84

which, in turn, is attached to a linear actuator 86. The linear actuator 86 is supported by the frame structure 16.

[0041] In operation, activation of the linear actuator 86 drives the shafts 82, and, thus, lift plate 74, upward and downward in response to a command from a controller. The upward motion of the actuator causes the lift plate 74 to pivot the lift block 78, thus raising the lids 62 off the container 34. Conversely, downward translation of the actuator drives the lift plate 74 and lift blocks 68 downward, causing the lids 62 to close.

[0042] Referring to Figures 3 and 4, the drive assembly will now be described. The drive assembly 28 includes a motor 90 which rotatably drives one or more sprockets 92, 94, preferably through a reducer 96. In the illustrated embodiment, the motor 90 drives two sprockets. The first sprocket 92 is used to rotate the outer drum 32 and the second sprocket 94 is used to rotate the containers 34. If it is desired to not drive the outer drum 32, the first sprocket need not be used.

[0043] It should be readily apparent that there are a variety of devices and systems for transmitting torque from a motor shaft to a drive shaft, such as gears, chain drives, and pulleys. Hence, the sprocket system disclosed is simply one configuration that can be used in the present invention.

[0044] The drive system includes a first belt 98 which is disposed about the first sprocket 92 and a drum sprocket 100. The drum sprocket 100 is splined or otherwise attached to the lower end of the drum shaft 40 such that the drum sprocket 100 and drum shaft 40 rotate in combination. A belt tensioner 102 is positioned adjacent to the belt 98. Belt tensioners are well known in the art for providing tension in belt drive systems.

[0045] A second belt 104 is disposed about the second sprocket 94 and a container sprocket 106. The container sprocket 106 is splined or otherwise attached to the lower end of the drive shaft 36 such that the container sprocket 106 and drive shaft 36 rotate in combination. A belt tensioner 108 is also positioned adjacent to the belt 104.

[0046] The drive system is controlled in a similar manner as described in U.S. Pat. Nos. 5,355,638 and 5,848,929. According no further discussion is needed. The sizes of the sprockets are selected so as to provide the desired relative speed between the outer drum and the containers.

[0047] A controller 200 (shown in Figure 1), such as a signal processor, electronic or digital controller or other type of control system, is used to control the motor's speed and direction of rotation, as well as the actuation of the linear actuator for lifting the lid assembly. Controllers are well known to those skilled in the art and, therefore, no further discussion is needed.

[0048] As described above and in U.S. Pat. Nos. 5,355,638, a traction interface is preferably provided between a portion of the container 34 and the inner surface of the outer drum 32. The traction surface causes the container to roll along the inside surface of the drum, thereby imparting rotational motion to the container. The traction surface also transfers momentum from a rotating outer drum to the container when the outer drum is rotating at a different rotational speed and possibly in a different direction than the rotational movement causing the revolution of the inner container.

[0049] The traction surface eliminates the need for a complicated gearing system or a separate belt for each container, resulting in a simpler apparatus with reduced maintenance requirements relative to the prior art. Use of the traction surface, also greatly reduces overall vibration resulting in cooler and quieter operation as compared with many prior art machines.

[0050] In the illustrated embodiment, the traction surface 150 is formed as a ring of resilient and relatively soft material having a high coefficient of static friction, such as rubber or urethane. The traction surface may have a range of compressibility, from soft to rigid, depending on the application. The traction surfaces are described in detail in U.S. Pat. Nos. 5,355,638 and 5,848,929. According no further discussion is needed.

[0051] The present invention is designed to induce high centrifugal and rotational forces on an object placed within the container. In order to accommodate the high loading attendant to the present invention, the containers

and drum should be made from high strength material, such as steel. The frame structure and drive system must also be designed to accommodate the anticipated high loads. Those skilled in the art would be readily capable for selecting the appropriate materials to support the anticipated speeds and loads associated with the present invention.

**[0052]** The high centrifugal and rotational force generated on an object using the present invention can be used for fast and precise processing, including finishing, resulting in a superior product with enhanced properties. The high speeds that the present invention is capable of inducing on abrasive media and products contained within the container will result in cold plastic deformation occurring on the surface of the products being processed. Various objects can be processed using the present invention including, but are not limited to, any of those products identified in U.S. Pats. Nos. 5,355,638 and 5,848,929.

**[0053]** The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification, as indicating the scope of the invention.

**[0054]** What is claimed is: